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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 767

Contribution from the Bureau of Animal Industry
JOHN R. MOHLER, Chief

Washington, D. C. PROFESSIONAL PAPER April 28, 1919

OAK-LEAF POISONING OF DOMESTIC ANIMALS

By

C. DWIGHT MARSH, Physiologist in Charge of Poisonous Plant Investigations, A. B. CLAWSON, Physiologist, and HADLEIGH MARSH, Veterinary Inspector, Bureau of Animal Industry

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HISTORICAL SUMMARY AND REVIEW OF LITERATURE.

Although the literature on poisoning by acorns is extensive, publications on poisoning by oak leaves are comparatively few. The earliest recorded statement regarding the injurious properties of oak leaves is by Mascal, 1662, page 243,[1] who says "Again oak leaves, if sheep eat thereof green, it is evil for them, especially for young lambs, which will kill them; and likewise of other cattel."

Apparently there was no other reference to this subject until 1893, when Cornevin treats of it quite fully. As this is the only extended account in the literature and as his work is not common in libraries, his statement is quoted in full (by translation) as follows:

There are no less than 300 species of the genus Quercus. For our purpose we consider only one, the most common. Moreover what is said about this will apply to the others.

Quercus robur, L. (Chêne rouvre).—According to many botanists we should unite under this Linnean species the two varieties *Q. pedunculata* Thrh. and *Q. sessiflora* Smith as well as the forms derived from them, especially *Q. Cerris* and *Q. pubescens* Wills.

[1] For complete titles of works cited see list of literature on page 36.

The oak is so common that it is unnecessary to give a botanical description in this place. We may recall the fact that the fruit at its base is placed in a cup, which is pedunculated in the variety under consideration, but sessile in *Q. sessiflora*, while the opposite condition exists in the leaves of the two forms.

Independently of the wood and the tan bark which it furnishes for manufacture and fuel, the oak annually provides for the food of animals its acorns, and, in some regions, its leaves.

It is to the leaves exclusively that it is necessary to call attention; they occasion in the live stock which consume them, under some special conditions, accidents of serious importance.

In the early spring in the low country, and a little later in the plateaux, when the buds of the trees of our forests are opening and the young leaves have still the light-green color which tints the country so beautifully in the spring, it happens that the farmers whose supplies of forage are exhausted pasture their animals in the forests. This is the custom of the inhabitants of the forests, of the charcoal burners, of the woodmen who work the cuttings, and is frequently a necessity for the small farmers of the wooded country. The cattle, for a long time accustomed to dry feed and finding little grass on the soil of the forest, eagerly eat the fresh twigs and young leaves upon them. If they are grazing in a thick coppice, their eagerness has no limit at first.

After some days of this feeding, there appears, at first only on young animals, and especially it has been noticed on those with a thin skin and white hair, then later in the milch cows and the rest of the herd, the symptoms of a disease observed and described for a long time under the characteristic name of "mal de brou" or of "maladie des bois." In the South it has been observed following grazing in lands where different shrubs grow, and especially the Spanish broom (Genêt D'Espagne) whence it is commonly called genestade.

Symptoms.—The animals, with a full appetite at first, eat less and less, they ruminate only a little, and apparently with difficulty; they are eventually affected with constipation, which increases and their excrement becomes hard and coated. They remain a long time lying down, and from time to time look at their flanks as in cases of dull colic, then get up and urinate. The liquid is emitted in jets and is then of a dark-red color. The secretion of milk in the females is lessened and eventually fails entirely. There is some fever, trembling of the muscles, and weakness of the hind legs, the coat is rough, the dorsolumbar region more sensitive than normal, the mouth cold, and the saliva reduced.

Three or four days after the onset of the disease the rumination is completely stopped, the patients stamp, exhibit colic, and have the abdomen drawn up; the pulse is hard, the heart action agitated, the respiration accelerated and labored, the shaking of the muscles violent, and they attempt to urinate frequently.

Always a striking symptom is the color of the urine; it is constantly dark, but with variations of shade which pass from a clear red to the deep dark color of Malaga wine, with the brown shade predominating.

If the animal is withdrawn from the cause of its illness and receives the necessary care for its condition it will most generally recover.

The prognosis is bad when the constipation is succeeded by a foamy dysentery with very fetid and abundant feces. Then the patients very quickly become feeble, and die in a condition of marasmus.

In the great majority of cases the "mal de brou" does not make rapid progress; nevertheless, there occurs, exceptionally, a kind of sudden explosion of illness. There is a sudden and abundant expulsion of bloody urine with violent colic and sometimes intestinal hemorrhage; under these conditions the patients have succumbed in 24 hours.

Lesions.—They are those of gastroenteritis and of nephrocystitis. The first are generally closely related to the intensity and progress of the disease. The second are more accentuated. The kidneys are doubled or tripled in volume, show ecchymotic spots on their surface, hemorrhagic foci in their parenchyma, inflammation of the pelvis and the destruction of the uriniferous tubules or their obstruction by fibrinous coagulum. The bladder is almost always turned back upon itself and is nearly empty or contains a small quantity of dark urine; the mucous membrane is inflamed.

The study of the urine, which is the more interesting part in the history of hematuria, has been much neglected up to the last years. Only the most evident physical characters have been noted, and there has been established only one essential point, the presence of or absence of blood corpuscles in the urine. Stockfleth denies their existence in this liquid, while most French authors admit it. M. A. Robin has made a thorough study of the urology, and we can not do better than to quote a résumé of his observations.

"The urine is viscous, with alkaline reaction, with an ox-house odor, rich in sediment formed largely of coagulated albuminoid matter and tinted brown. The blood corpuscles are rare, but one finds crystals of urate of ammonia, a very little carbonate of calcium, some drops of oil, some leucocytes, no oxalate of calcium, a little urea in a normal condition, a considerable diminution of the hippurates and a notable increase of the chlorids, a little phosphoric acid, albumen in considerable quantity and also some urohematin and hemoglobin. No trace of sugar."

From his analysis, M. Robin concludes that during the course of the disease "the organism loses heavily in urea and especially in the chlorids, losses which become more evident as the animals eat less, that the uric acid replaces the hippuric, the urine of the sick animals approaching temporarily the condition of that in carnivores; that the salts of calcium diminish in the liquid and disappear in the sediment; that the free oil and the casts increase and appear in connection with the defervescence; lastly that the affection appears to be a hemoglobinuria rather than a true hematuria."

What is the substance producing this hemoglobinuria? It must be found in the young shoots and new leaves of the oak, but it is to be noticed that those of the hornbeam, ash, alder, hazel, privet, cornel, spruce, pitch fir, gorze, and broom under the same conditions are capable of producing similar results. All these shoots and leaves are rich in tannin, and investigators have been led to consider this body as the one producing the harm. We will discuss this opinion.

To sustain it, it can be argued that the tannin is in much larger proportion in the accused plants, and especially in the oak in the spring than in the winter, and that it is more abundant in the young oaks than in the old since in the latter the tannin is transformed to gallic acid and then little by little into brown extractives.

It is learned that the content of tannin in the plants containing tannin has relation to the physiological activity of the tissues in such a way that its maximum is found in the young organs, like the sprouts, young branches, and the first leaves, the forming tissues, the cambium and the phellogen.

Does it follow that it is a greater introduction of tannin into the economy which occasions the "mal de brou?" I do not think so. As a matter of fact animals are given food which is just as rich in tannin and which, nevertheless, occasions no accidents in spite of the continuance of such treatment. We may mention the acorns which in the wooded districts, in France and elsewhere, are given to all animals, horses, fattening animals, and swine, without ever bringing on hematuria, but with excellent results. The leaves of the vine are, among foliaceous organs, especially rich in tannin—from time immemorial these have been collected and preserved in silos as food for animals in winter. Who has ever known the "mal de brou" to follow their consumption? In the Scandinavian country, in the north of Russia and of Asia, especially among the Baskir tribes, they use the bark of the birch, pine, spruce,

elm, wild cherry, linden and willow, having an equal content of tannin, for feeding the animals during the winter, and no inconvenience or accident results.

The experiments, partly with tannin, partly with tannic acid made by the pharmacologists, no more prove the harmfulness of these substances or the production of hemoglobinuria. Gohier has performed in this line an experiment often quoted. He fed large quantities of oak bark to horses, which came out with good results; he proved an arrest of digestion with obstinate constipation, but without hematuria. Their blood, far from having a tendency to lose its hemoglobin, became more red, more coagulable, and much slower in putrefying.

Moreover the therapeutic investigations made with tannic acid employed as pure as possible have not disclosed hematuria following its use for a long time.

Finally we may add that the consumption of the leaves of oak, ash, etc., in summer, autumn, and winter at a time when they contain a much smaller proportion of tannin than in the spring, it is true, but still in large quantity, does not bring on the "maladie des bois." In the mountain region of the southeast and center, especially in the high and low Alps, the Lozère, the Ardèche, the Haute-Loire, the Rhône, etc., they cut in autumn the leafy branches of the oak growing from the pollards, and with these they feed the sheep for a long time without accident.

If the tannin of the bark, fruit, and leaves of summer and autumn can not be blamed, two hypotheses are presented; there may exist in the young leaves along with the tannin an ephemeral poisonous substance, which soon disappears, or the tannin itself may come into a special condition which may give it the harmful properties which have been described.

The first hypothesis is hardly tenable for it would be very singular if this poison should have, up to the present time, escaped the notice of the chemists and botanists, who have studied tannin so thoroughly. We can not deny it absolutely, for we can not pledge the future, and can not foresee what may ultimately be discovered, but we expect the facts will support this belief.

Let us look at the second. It is admitted nowadays that plants hold the tannin under the form of a polygallic glucoside which is easily changed. The varieties of this are many, following the plant species which furnish them. It is probable that in the same species many of these varieties, derived one from the other, appear and disappear to make way finally for the specific variety. It will be very desirable that the chemists should study this point, commencing their analyses with the opening of spring. The check of its plant histology should not be neglected. We possess, actually, many good reagents which can furnish useful information: the perchlorid which colors green or blue, according to the character of the tannin; the bichromate of potassium which forms a compact reddish-brown compound and the solution of molybdate of ammonia in a concentrated solution of chlorhydrate of ammonia, which colors the tannin red and has the advantage of making it possible to distinguish the glucosides of tannin from the tannic acid, for an excess of the chlorhydrate of ammonia produces in the first voluminous precipitate, while the last remains colored red.

These varieties of tannin, very changeable as has been said, may suffer modifications in the plant economy and furnish sometimes acids, sometimes special bodies like pyrocatechin.

Now, some very interesting investigations of M. C. Hayem have shown that the blood of animals submitted to the action of pyrogallic acid and pyrocatechin shows special modifications. The blood corpuscles are attacked and a certain proportion of hemoglobin extravasated. There is a formation of methemoglobin at the same time in the red corpuscles and in the plasma and more or less intense degeneration of the corpuscles. On the other side it has been established that in hematuric fever and in paroxysmal hemoglobinuria, the urine contains methemoglobin.

Do not all these ideas combine to make us admit the possibility of a particular state of the tannin in the young tissues and the modification of this tannin in the animal economy?

However this may be, the farmer should see from this and what precedes that if feeding with gathered leaves in the summer and in autumn raises no objection because it brings no inconvenient consequences, it is not the same when the collection is made in the beginning of spring and contains shoots and very young leaves. The better way will be not to subject the animals to it.

Before closing we should say that the employment of sawdust of oak wood as a litter is not to be recommended. It furnishes an acid manure that can only be usefully employed after being corrected by phosphates. This litter is also accused of attacking in time the udders of milch cows and of occasioning inflammations.

Harting, 1901, says that goats eat oak twigs without injury, but deer and cows are fatally poisoned.

Mackie, 1903, published a paper on the value of oak leaves for forage. He gives chemical analyses of a number of species and discusses their comparative value as forage. His general conclusion is that the oaks have a fairly high nutritive value, deciduous species being better than the live oaks. He does not intimate that the leaves have any poisonous properties.

In the Breeder's Gazette of September 1, 1909, page 362, occurs the following short article:

OAK LEAF KILLS CATTLE.

Stockmen grazing cattle in the national forests in the southwest, especially in Colorado and New Mexico, have suffered serious losses during the present summer through the cattle eating oak leaves. In that section of the country the season has been unusually dry and grass extremely scarce. To eke out the scanty forage supply the cattle have browsed on the scrub oak which covers large portions of the range. Ordinarily the stock does not browse much on the oak and the little they do get, taken with the other food, is not injurious, but when, as in the present season, the oak browse furnishes a large proportion of the daily food of the cattle, the results are serious.

The oak leaves and sprouts contain a large percentage of tannic acid. The action of this acid on the stomach is extremely injurious and the losses have been unusually severe. The symptoms of the disease are staring eyes, feverish and blistered lips and nose, the animal ceases to graze or seek for food, standing in one place for hours at a time. The coat becomes rough and the hair is all turned the wrong way, as in cases of loco poisoning. The animal does not chew its cud and in a comparatively short time it becomes too weak to remain on its feet and death rapidly follows. So far as is known the only remedy available for this trouble is linseed oil given as a drench in amounts from 1 to 2 quarts. The oil appears to overcome the injurious effects of the tannic acid, and if the disease is not advanced too far and the animal can be furnished sufficient food so it will not be forced to eat the oak, it will generally recover. The best method, of course, in handling the trouble is, if possible, to get the cattle away from the range where the oak is found and furnish them with plenty of fresh green feed to build up again.

Lander, 1912, page 270, makes a brief statement which is evidently based on Cornevin.

Barnes, 1913, pages 268 and 278, treats of the subject, making practically the same statements which were made earlier in the Breeder's Gazette.

Glover and Robbins, 1915, page 25, speak of the subject as follows:

> Scrub oak is considered poisonous by many stockmen. They will take the pains to keep their stock from the oak thicket. It is very likely that most cases of poisoning resulting from cattle grazing in scrub-oak thickets are due to larkspur which grows therein.

The foregoing covers all the literature that has been found on the subject of poisoning by oak leaves. It may be noted that the bibliography is surprisingly small, and that even the somewhat extended account of Cornevin contains much theoretical matter and is not supported by experimental evidence.

POISONING BY OAK LEAVES IN NORTH AMERICA.

Throughout the grazing region of the West there is a very general belief in the poisonous properties of oak leaves, more particularly with regard to their supposed toxic properties for cattle. Heavy losses are said to have been caused in certain localities, and many inquiries have been addressed to the Department of Agriculture for information concerning the disease and its treatment. In connection with the investigations of poisonous plants and their effects there has been an attempt to collect all available information on the subject, and feeding experiments have been carried on during four summers.

As has already been indicated, the published statements with regard to poisoning by oak leaves in America are very few. The Department of Agriculture, however, has received by correspondence considerable information on the subject which may be summarized as follows:

Localities of supposed poisoning.—The States from which most of the complaints have come are Colorado, Utah, New Mexico, and Texas. Many of the reports have come through forest supervisors, the following national forests being represented: San Isabel, Las Animas, Nebo, Fillmore, La Sal, Wasatch, Manti, and Fishlake. It may be noted that the Utah national forests are largely represented, and more detailed complaints have come from that State than from the others.

Species supposed to be poisonous.—Of course, the reports ordinarily do not connect the disease with any one species. It is evident, however, from our knowledge of the local flora in the places from which the complaints come, that most of the trouble is ascribed to two species, *Quercus gambellii* Nutt. and *Q. havardi* Ryd. The latter species is popularly known in Texas and New Mexico as the "shinnery" oak, and the plant is said to "shinnery" cattle.

Season when poisoning occurs.—While many of the reports are indefinite as to whether poisoning is more likely to occur at particular seasons of the year, there is a general agreement that most cases

occur in the spring. Some say that all cases are in the spring. Most observers say that the harmful effects are produced by eating the buds and young leaves. Some say that these are most harmful after being frosted. It has been noted by many that cattle in poor condition in the spring of the year are most liable to be affected, and that if well fed they are not harmed.

Symptoms.—The symptoms described by Cornevin included loss of appetite, cessation of rumination and lactation, fever, trembling of muscles, dark-red urine, and constipation followed by dysentery; the autopsies showed gastroenteritis and acute nephritis.

The reports from supposed oak-brush poisoning in the United States do not agree very closely with Cornevin's description. Barnes, 1913, gives the prominent symptoms as fever, scabby sore nose, deep-set eyes, hair turned the wrong way, difficult breathing, and contents of stomach compacted, the material being dry and burned.

From the reports of different stockmen may be added as characteristic symptoms, constipation, dark or bloody feces, and emaciation; it is said by some that an examination of the stomach contents shows masses of oak leaves, and that the material in the third stomach is dry and hard. Some of the cases are said to be acute but many linger along for weeks and months.

Animals poisoned.—The principal complaint is of cattle, although sheep have been reported as affected by oak. It may be noted that the European authors, Cornevin more particularly, apparently consider cattle the principal sufferers, though sheep and deer are mentioned. Harting says that goats are not injured.

EXPERIMENTAL WORK WITH SCRUB OAK.

A considerable number of so-called oak-brush cases have been seen upon the range in Utah and Texas. These animals exhibit the common symptoms of emaciation, sunken eyes, weakness, and bloody feces. Autopsies have shown a gastroenteritis and sometimes a pathological condition of the liver which might be explained by parasitism. The temperature in observed cases was subnormal rather than one indicating fever. The general condition of the animals closely resembled that exhibited by locoed animals. This condition in Utah is known as "summer sickness" as well as "oak-brush poisoning."

During four summers, 1915, 1916, 1917, and 1918, feeding experiments were conducted with cattle at the Salina experiment station, Utah, to determine whether feeding upon oak leaves is harmful. All these experiments were with the scrub oak of Utah, *Quercus gambellii.*

The table following gives a summarized statement of the feeding experiments:

Summary of four years' feeding experiments of cattle with scrub oak (Quercus gambellii) at Salina Experiment Station, Utah, 1915 to 1918.

Cattle No.	Weight of animal	Date of feeding.	Part of plant used.	Weight of plant fed.		Number of days of feeding.	Average daily feed per 1,000 pounds of animal.	Severity of sickness.	Remedy.	Result.	Remarks.
				Total.	Per 1,000 pounds of animal.						
	Pounds.	1915.		*Pounds.*	*Pounds.*	*Days.*	*Pounds.*				
674	600(?)	June 23 to 25	Leaves	27	45(?)	3	15?	Not sick	None		
692	300(?)	June 23 to July 2.	Leaves and twigs	104.5	348(?)	10	34.8	Became thin and weak	do	Recovery	Refused to eat oak just before turned out.
674		June 27 to 30	Leaves			4		Not sick	do		
676		July 4 to Aug. 24.	do			52		Constipation	do	Recovery	On 2 days received about 10 pounds of weighed leaves.
679		do	do			52		do	do	do	Do.
685		Aug. 24 to Sept. 20.	do			28		do	do	do	
691		do	do			28		do	do	do	
		1916.									
712	432 to 466	May 31 to June 16.	Twigs and buds	211.25	489	17	28.8	do	do	do	Fed alfalfa hay June 1, 6, 8, 10, and 16.
712	466 to 486	June 17 to 19	Small leaves	36.75	78.8	3	26.3	do	do	do	Fed alfalfa hay June 18 and 19.
702	448 to 502	June 7 to 16	Twigs and buds	133	296.9	10	29.69	Constipation, bloody feces.	do	do	Fed 2½ to 3½ pounds alfalfa hay June 8, 10, 11, 12, 13, 14, 15, 16, 17, 18, and 19.
702	500	June 17 to 19	Small leaves	33.5	67	3	22.3	do	do	do	
732	520 to 465	June 21 to 27	Leaves			7		Loss of weight			Ate very little.
715	360 to 332	do	do			7		Not sick			Do.
703	636 to 614	June 21 to Aug. 4	do			45		Constipation			In pasture 8 times.
704	662 to 615	June 28 to Aug. 4	do			38		do			In pasture 8 times; fed alfalfa hay once.
731	539 to 580	June 28 to Sept. 9	do			74		Constipation, bloody feces.	None	Recovery	From Aug. 11 fed daily 3 pounds alfalfa hay; in pasture 8 times.
722	506 to 538	Aug. 5 to Sept. 9.	do			36		Not sick			From Aug. 11 fed daily 3 pounds alfalfa hay.
723	493 to 580	Aug. 5 to Sept. 17	do			44		do			Do.
703	812 to 812	Sept. 10 to 17	do			8		do			Fed daily 3 pounds alfalfa hay.
704	760 to 765	do	do			8		do			Do.
		1917.									
758	435 to 482	June 11 to July 26.	Buds, leaves, and flowers.			46		Mucus in feces	None	Recovery	

770	372 to 377	June 11 to July 19.	....do....		39		Constipation, feces with mucus and blood.	Linseed oil..	Death.....	
772	456 to 396	July 10 to 22.....	Leaves.....		13		....do....	None.....	....do.....	
765	426 to 350	July 10 to 26.....	....do....		17		Constipation, bloody feces, loss of weight.	....do.....	Recovery....	
751	438 to 472	Aug. 2 to Sept. 9.	....do....		39		Not sick.....			Fed daily 3 pounds of alfalfa hay.
760	374 to 409	....do.....	....do....		39		....do.....			Do.
		1918.								
760	540 to 590	June 5 to July 4..	Buds, leaves, and flowers.		30		....do.....			Do.
763	482 to 552	....do.....	....do....		30		....do.....			Do.
808	622 to 604	July 11 to 24.....	Leaves.....		14		Feces, with mucus and blood.	Epsom salt..	Recovery....	Recovery not due to the remedy.
814	354 to 347	July 12 to 24.....	....do....		13		Bloody feces, dry nose.	....do.....	....do.....	Do.
761	758 to 718	Aug. 15 to Sept. 10	....do....		27		Constipation, bloody feces.	None.....	....do.....	

EXPERIMENTAL FEEDING OF CATTLE IN 1915.

In 1915 oak leaves were fed to seven head of cattle. To two of these, Nos. 674 and 692, weighed amounts of the leaves were fed. Unfortunately there were no facilities at the experiment station at that time for weighing the cattle, so that the weights of the animals were estimated and the ratios of the quantity fed to the weights of the animals are only approximate.

Cattle No. 674 received from June 23 to June 25, 27 pounds of leaves with no effect. This was probably in the ratio of about 15 pounds daily to 1,000 pounds of animal.

FIG. 1.—Cattle No. 676, June 20, 1915, to which oak leaves were fed experimentally.

Cattle No. 692, commencing with June 23, was fed leaves and twigs for 10 days, receiving a total of 104.5 pounds. This was probably not far from 35 pounds daily to 1,000 pounds of live weight. The animal lost flesh and remained thin and weak after being turned out in the pasture.

Five cattle, Nos. 674, 676, 679, 685, 691, received oak-brush leaves, the branches being thrown into the corrals and the animals picking off the leaves. This method was used partly to avoid the labor of gathering the leaves for feeding, but more particularly because in this way the animals ate a larger quantity. In this way, too, there was an approach to the natural conditions of grazing. The animals

were fed on oak leaves exclusively and for periods varying from 4 days in the case of No. 674 to 52 days in the cases of Nos. 676 and 679. Inasmuch as the cattle could not be weighed the records do not show exactly the effect of the feeding on the weights. It was evident, however, that all lost in flesh. This might be expected even if the oak had no injurious properties, for it does not have the nutritive value of the grasses, and then the cattle would not do so well on any one form of forage as they would if their feed offered some variety. All were somewhat constipated but showed no other undesirable symptoms; this constipation was not a serious matter

FIG. 2.—Cattle No. 676, August 24, 1915, to which oak leaves were fed experimentally.

and while the animals lost some flesh, all presented a fair appearance at the close of the experiment. The photographs of the two animals, Nos. 676 and 679, figures 1, 2, 3, and 4, taken June 20 and August 24, show that they did not suffer materially from the experiment.

The results of the cattle feeding in 1915 left the whole subject in much doubt. Some of the cattle were constipated and did not thrive, but this in part might be explained away. It seemed clear that feeding on oak browse might be continued for a considerable period without necessarily producing injurious results but that possibly in some cases more or less injury might follow.

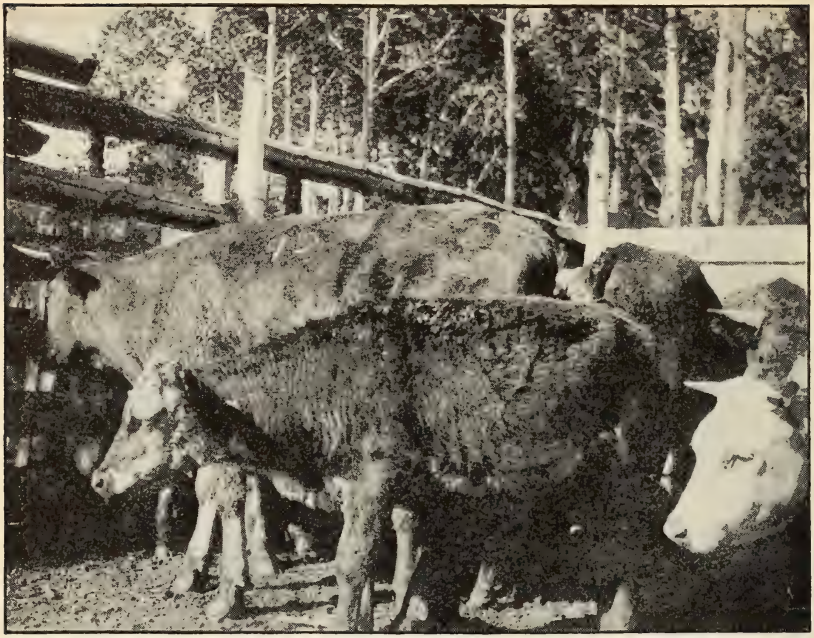

FIG. 3.—Cattle No. 679, June 20, 1915, to which oak leaves were fed experimentally.

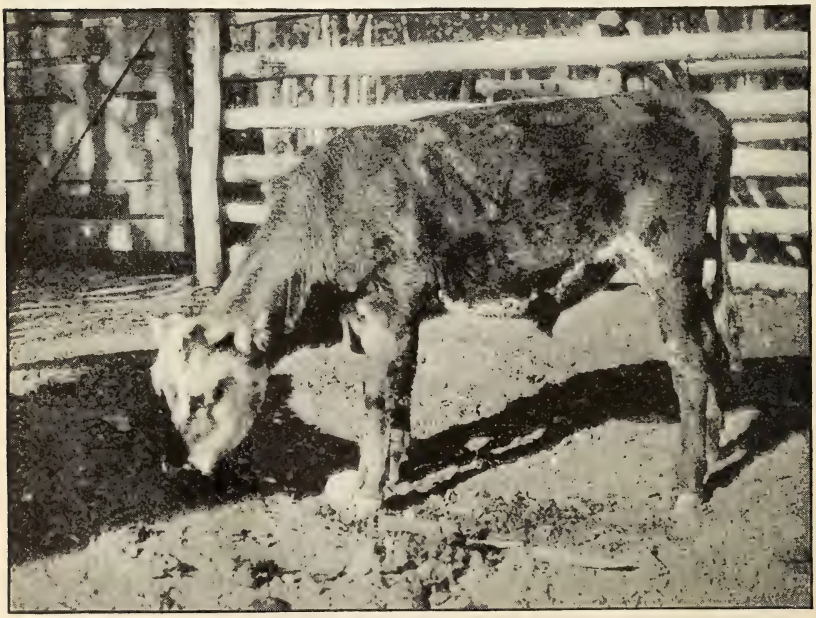

FIG. 4.—Cattle No. 679, August 24, 1915, to which oak leaves were fed experimentally.

EXPERIMENTAL FEEDING OF SHEEP IN 1915.

An attempt was made to feed four sheep, but three refused to eat the oak. The experiment was continued with one, No. 327, for 30 days. This one received an average of 2 pounds daily per hundredweight of animal. The oak was fed with chopped hay one day at the beginning of the experiment, but with this exception it received oak leaves exclusively. Its weight fell from 74.5 pounds to 66.5 pounds, but no other bad effect was noted.

EXPERIMENTAL FEEDING OF CATTLE IN 1916.

Two experiments on the feeding of buds and twigs were conducted with cattle Nos. 702 and 712. No. 702 received buds and twigs from June 7 to June 16, and small leaves from June 17 to June 19. No. 712 received buds and twigs from May 31 to June 16 and small leaves from June 17 to June 19. Both animals were treated in the same way, the only difference being that No. 712 was fed for a longer time. During the experiment they were kept in the corrals and were fed exclusively upon the oak, except that on 12 days each was given 3 pounds of alfalfa hay daily.

Careful clinical observations were made, the temperature and pulse being taken at stated times three or four times daily, and they were weighed frequently. The temperature and pulse showed no deviations from what might be expected in normal animals and followed a strikingly regular rhythm from day to day. The increase in weight was continuous. No. 702 weighed at the beginning of the experiment 448 pounds, and at the end 502 pounds. No. 712 during the same time, from June 7 to June 19, increased from 432 pounds to 486 pounds. Reduced to percentages of the original weight, No. 702 gained 12 per cent and No. 712, 12.5 per cent.

It is interesting to compare these gains with those of 23 other animals which were kept on pasture during the same period and which were weighed June 7 and June 22, thus covering nearly the same time as Nos. 702 and 712. The gain in these animals varied from 10.68 per cent to 25 per cent. One other animal that was in pasture was weighed June 7 and June 19 and had lost 8.4 per cent. The average gain of the 24 animals in pasture was 15.64 per cent. While the experiment animals Nos. 702 and 712 gained as much as the minimum of those on pasture, they did not come up to the average and it is probably fair to presume that they would have done better in pasture, yet this is by no means certain, as only two animals are concerned and it is possible that they would have fallen into the number of those with comparatively small gains. Moreover, this deflection from the average is not enough to indicate any serious effect on the cattle feeding upon oak. Figures 5 and 6 show the weight curves of Nos. 702 and 712. Both animals were constipated and once bloody feces were noticed in No. 702. No other symptoms were noted.

Six other cattle were fed on oak-brush leaves during the summer of 1916, the feeding being conducted, as in 1915, by throwing freshly cut oak brush into the corrals, where the animals picked off the leaves.

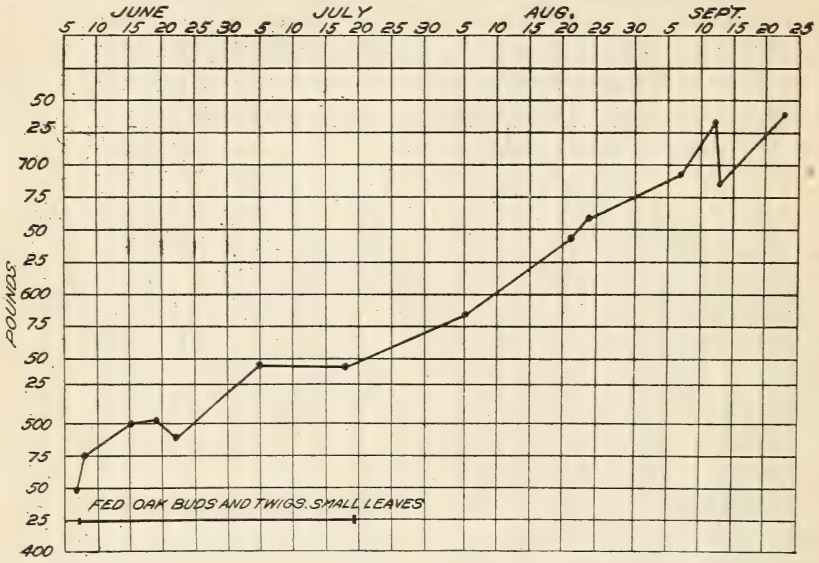

FIG. 5.—Weight curve of cattle No. 702, fed with 3 pounds of alfalfa hay per day from June 7 to July 19, 1916.

Nos. 715 and 732 were fed in this way from June 21 to June 27. Although nothing but oak was furnished them, both of these animals ate very little. They lost weight during the feeding, but showed no other ill effects. No. 732 did not make a normal gain during the rest of the summer, but there was no reason to think that this lack of gain was a result of the oak feeding.

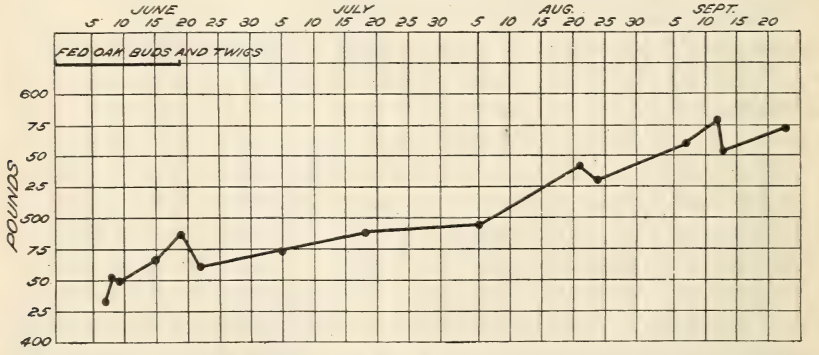

FIG. 6.—Weight curve of cattle No. 712, fed oak from May 31 to June 19, 1916, with 3 pounds of alfalfa hay per day on 12 days.

Nos. 703 and 704 received oak brush—703 from June 21 to August 4 and 704 from June 28 to August 4—and these animals were given oak brush with 3 pounds of alfalfa hay each, from September 10

to September 17. During the first period there was a loss of weight in No. 704, followed by a sharp gain. No. 703 during this period maintained its weight, on the average, and also showed a marked

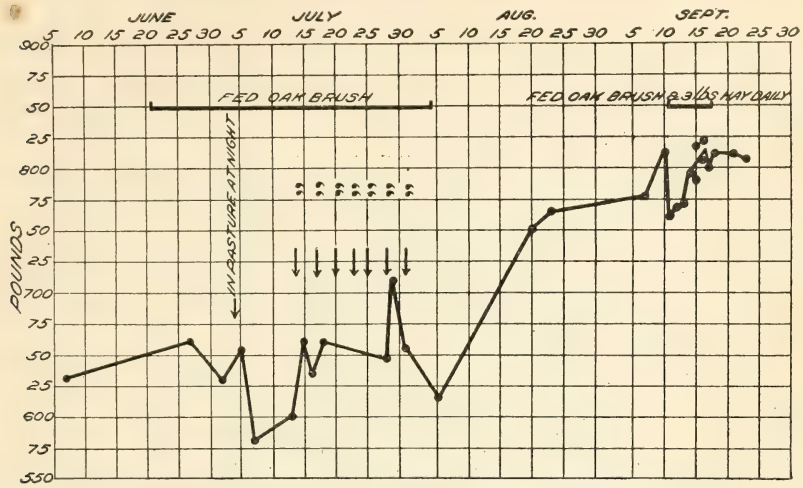

FIG. 7.—Weight curve of cattle No. 703, fed oak from June 21 to Aug. 4, 1916, and oak with alfalfa hay from Sept. 10 to 17, 1916.

gain when turned into the pasture. During the second period, when 3 pounds of alfalfa hay were given daily to each animal in addition to the oak, both animals maintained their weight. Presumably,

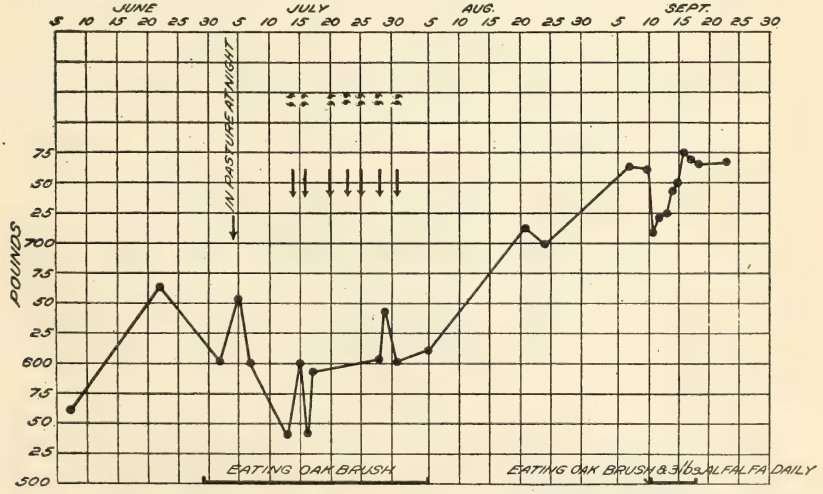

FIG. 8.—Weight curve of cattle No. 704, fed oak from June 28 to Aug. 4, 1916, and oak with alfalfa hay from Sept. 10 to 17, 1916.

judging from the recorded weights of cattle in the pasture, Nos. 703 and 704 would have made distinct gains if they had been kept in the pasture. Figures 7 and 8 show the weight curves of Nos. 703 and 704.

It may be noted that No. 704 was under observation in 1917 and made normal gains.

No. 723 received oak brush from August 5 to August 10, and from August 11 to September 13 received oak brush and 3 pounds of alfalfa hay daily. This proved to be a maintenance ration. No 723 had been gaining during the season, but during the feeding remained at a standstill, while under favorable conditions it probably would have continued to make gains.

No. 722 received oak brush from August 5 to August 10 and oak brush with a daily ration of 3 pounds of alfalfa hay from August 11 to September 9. The result was almost identical with that in the case of No. 723. In both cases, while the gain continued for some days after the oak feeding was commenced, the result of the whole period was to stop the gain.

No. 731 received oak brush from June 28 to August 10, and oak brush with a daily ration of 3 pounds of alfalfa hay from August 11 to September 9. It lost weight up to about August 5 and then made a continuous gain through the remainder of the period of feeding. No. 731 was constipated, and at one time during the feeding exhibited bloody feces.

Most of the sheep fed on oak brush were constipated, but showed no other symptoms. Moreover, the constipation was not of a serious character.

The work of 1916 modified the results of 1915 by showing definitely that feeding upon oak browse may produce constipation and bloody feces, but it could not be inferred that so-called oak-brush poisoning is a very serious matter. It also appeared that probably a daily ration of hay, in addition to the oak, would prevent ill results. It should also be noticed that all the animals fed on oak exclusively were fed for a comparatively short time.

EXPERIMENTAL FEEDING OF CATTLE IN 1917.

In 1917 six head of cattle were used in the experimental feeding. In all cases the animals were fed in the corrals, cut branches of the oak being brought in, as in 1916, and the cattle ate the buds, flowers, and leaves from the branches much as they would when grazing upon the range.

Two cattle, Nos. 758 and 770, were fed early in the season and received at first buds, flowers, and small leaves, and later the mature leaves. As the season of 1917 was late, these animals were fed as soon as the foliage had started on the oaks.

No. 758, a steer, was fed from June 11 to July 26, 46 days, having nothing but oak, until June 25 the feeding was buds, flowers, and small leaves; after that date full-grown leaves were used. On June 24 the animal was somewhat constipated and at this time and at intervals during the remainder of the feeding the feces contained

more or less mucus, indicating intestinal irritation. The steer made no gain in weight during the time it was eating oak, but after being put on pasture at the termination of the experiment, July 27, gained rapidly. (Fig. 9.)

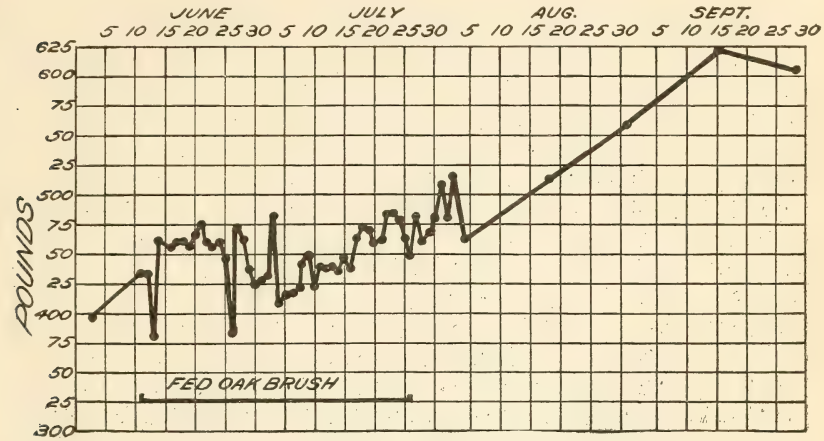

FIG. 9.—Weight curve of cattle No. 758, fed oak from June 11 to July 26, 1917.

No. 770, a steer, was fed with No. 758, having the same course of treatment. Early in the experiment the animal became much constipated, this condition being very marked by June 19. The feces contained much mucus and more or less blood. As the experiment proceeded, the animal ceased to eat freely of the oak and on

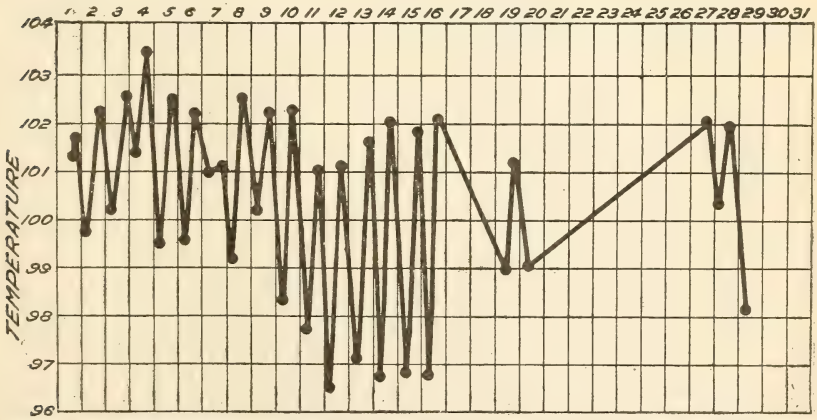

FIG. 10.—Temperature curve of cattle No. 770 during July, 1917; fed oak from June 11 to July 26, 1917.

July 6, 7, and 8 a daily ration of alfalfa hay was added. By July 13 it was in poor condition, standing in a dejected attitude, with its head extended in a position that seems to be typical of bad oak-brush cases. Much of the time it was lying down. The pulse became

slow and weak and the variation between morning and afternoon temperature greater than in a normal animal, the morning temperature being very low (see fig. 10). On July 17 it was turned into pasture to graze, but was brought in again July 19 and given feedings of oak brush. July 20 it was returned to pasture and brought into the corral on July 27. At this time it was very weak and the feces were composed largely of bloody mucus. It was given 500 cubic centimeters of raw linseed oil. On July 28 its eyes were sunken, and in the afternoon its pulse became almost imperceptible. On the morning of July 29 it was lying upon its side, groaning, pulse imperceptible, breathing with difficulty, and died at 11.30 a. m.

At the autopsy deep congestion was found in the duodenum, jejunum, ileum, cecum, anterior part of the colon, and about 5 inches

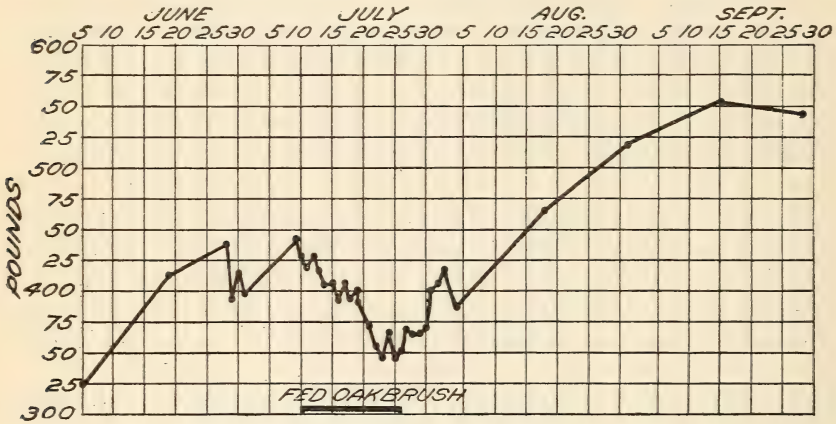

FIG. 11.—Weight curve of cattle No. 765, fed oak from July 10 to July 26, 1917.

of the rectum. In the epidermal space of the spinal column there was an excess of serous coagulum. Otherwise the organs were normal.

On July 10 feeding of oak leaves was commenced with cattle Nos. 765 and 772. These animals were kept in the corral and fed upon oak exclusively.

No. 765 was fed from July 10 to July 26. On July 21 it was noted that the feces were hard and bloody, and from this time the animal was very much constipated and showed marked depression. The coat was rough and the nose dry. From the beginning of the feeding it progressively lost weight, as shown in figure 11. There was nothing abnormal about the pulse and respiration rates. The difference between morning and afternoon temperature was rather greater than normal. July 26 it was fed some alfalfa hay with the oak, and on the next day it was kept in pasture. From this time until August 4 it was kept in pasture part of the time and part of the time fed in the corral with hay. On August 4 it was turned

into pasture, where it was kept under observation until September 28. During this time it gained in weight and regained its normal condition.

No. 772, a steer, was fed with No. 765. By July 22 it had lost its appetite and was much constipated, its feces being not only hard but also containing blood and mucus. It had progressively lost weight from the beginning of the feeding. Its pulse became weak in the succeeding days, its eyes sunken, the nose dry, and the animal became very weak and was lying down most of the time. A little hay was given it, but it gradually grew worse, the feces became more liquid, and contained much blood and mucus. The pulse became indistinguishable, and it died on the morning of July 27.

At the autopsy dark, hemorrhagic areas were found on the pericardium and the surface of the heart. There was some peritoneal

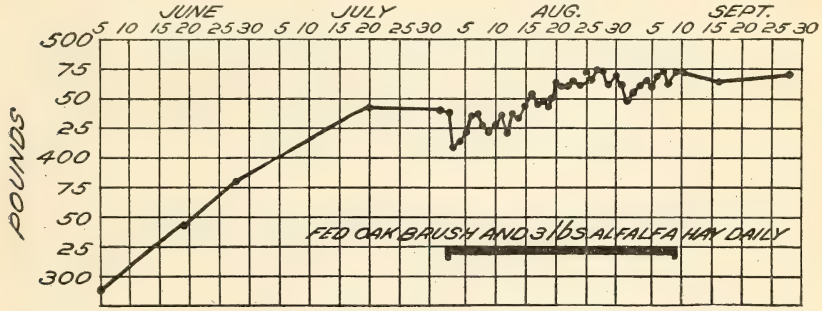

FIG. 12.—Weight curve of cattle No. 751, fed oak and 3 pounds of alfalfa hay per day from Aug. 21 to Sept. 9, 1917.

inflammation but no adhesions. Congestion was present in the duodenum, the anterior part of the jejunum, the ileum, and the rectum. The large intestine showed slight congestion. The liver appeared abnormally fibrous, the gall bladder was filled with gelatinous bile; apparently the bile was dammed up, as there was no evidence of bile in the duodenum. The history of the animal showed no marked abnormalities in the temperature or the rates of the pulse and respiration. It should be noted that this animal died after feeding upon oak only 13 days.

Two steers, Nos. 751 and 760, were fed oak leaves from August 2 to September 9. With the oak each was given 3 pounds of alfalfa hay daily. These feedings were to check up the 1916 experiments with cattle Nos. 703, 704, 722, 723, and 731, in which alfalfa hay was fed with the oak, with no resulting ill effects from the oak feeding. Figures 12 and 13 show the curves of weight of Nos. 751 and 760. It will be seen that they were practically at a standstill during the period of the experiment. No symptoms of ill effect were noted, however, other than failure to make the gain which would be expected at that time of the year.

The inference from this experiment and the one of the preceding year is that a small hay ration will prevent such ill effects as follow an exclusive diet of oak leaves. The cases of 1917 supplemented the work of the preceding years by furnishing positive evidence of the possibility of oak poisoning and in giving fairly clear pictures of the symptoms and pathology.

EXPERIMENTAL FEEDING OF CATTLE IN 1918.

The work of the three preceding years at the Salina station, with the investigations at Monahans, Tex., which are described on pages 21–29, was considered to have proved definitely the possibility of oak poisoning, showed the symptomatology and pathology, and made it probable that a comparatively small quantity of other forage would prevent the ill effects of the oak. The experiments of 1918 were intended to clear up certain matters that were still in doubt.

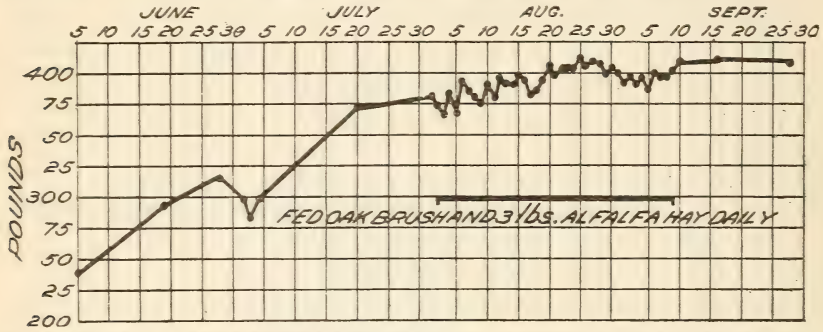

FIG. 13.—Weight curve of cattle No. 760, fed oak and 3 pounds of alfalfa hay per day from Aug. 2 to Sept. 8, 1917.

EPSOM SALT AS A REMEDY.

From the fact that oak-poisoned animals are constipated it was thought possible that treatment which would relieve this condition might prevent the illness. Cattle Nos. 808 and 814 were fed upon oak leaves in the corrals from July 12 to July 24 and each was drenched twice daily with 2 ounces of epsom salt. This remedy kept the bowels in a loose condition, but both animals exhibited blood and mucus in the feces, and showed other distinct symptoms of poisoning. It was evident from this that constipation was not the main factor in oak-brush poisoning.

POSSIBLE LOSS OF TOXICITY IN MATURE LEAVES.

The positive cases of the preceding years had been produced early in the season, and it is generally believed among stockmen that it is the young leaves and buds that produce poisoning. Moreover the experiments of feeding hay with the oak, which resulted in the continued well being of the animals, were carried on late in the season. It was possible that the fact that these animals were not poisoned was due to the lack of toxicity of the mature leaves rather

than to the beneficial effects of the hay. Therefore it was determined to try this experiment early in the season. Cattle Nos. 760 and 763 were fed on oak buds, flowers, and leaves from June 5 to July 4, and to each was given 3 pounds of alfalfa hay daily. Neither of these animals showed any ill effects from the oak. No controls were used with these animals, but the results of exclusive oak feeding at this season in preceding years make it reasonably certain that Nos. 760 and 763 would have shown symptoms of poisoning if they had not received the hay rations. This supplemented the work of the preceding years and made it probable that cattle would not suffer from oak poisoning at any season if other forage were provided. It should be added that experience at Monahans, Tex., indicated clearly that hay was equally beneficial in the early stages of the oak.

Cattle No. 761 was fed entirely on oak from August 15 to September 10; lost weight, became constipated, and showed mucus in the feces. It was not badly affected, but was a clear case of incipient oak-brush poisoning. This was positive evidence of the possibility of oak poisoning by mature leaves. While probably more cases of oak-brush poisoning occur in the spring, due probably to the lack of other forage, they may happen at any season when the conditions are favorable.

EXPERIMENTAL WORK WITH "SHINNERY" OAK.

From March 20, 1917, to May 20, 1917, Mr. Clawson was stationed at Monahans, Tex., to study so-called "shinnery" oak (*Quercus havardi*) poisoning. Arrangements had been made by Mr. W. N. Waddell, of Fort Worth, Tex., by which corrals and pastures could be used on the ranch of Estes and Brantley.

The soil near Monahans is sandy, with areas of gypsum rock, and the vegetation consists largely of shinnery oak, mesquite, bear grass (Nolina), some sage, some grama grass, and a few weeds, the grass and weeds appearing in rather small numbers after rains. In the early spring the vegetation consists essentially of oak, mesquite, bear grass, and sage. As seen over most of the range, the oak is a low-spreading shrub a foot or two in height. Where it has been protected from grazing it may grow from 3 to 6 feet in height.

Figure 14 shows the condition of the shinnery on a grazed pasture March 27, 1917, and figure 15 the plants April 15, 1917, when they were in flower. Figure 16 shows a group of cattle April 3, 1917, grazing on a sandhill covered with shinnery, and in figure 17, taken on the same date, a 2-months-old calf is shown in the foreground eating shinnery. In the early spring the cattle eat very largely of the oak, as there is very little other forage.

It was found that the conditions of the locality were such as to make corral feeding impracticable. The cattle, however, are grazed in large, fenced pastures, with fixed watering places, at which wind-

FIG. 14.—*Quercus havardi*, shinnery oak, Mar. 27, 1917.

FIG. 15.—*Quercus havardi*, shinnery oak, in flower, Apr. 15, 1917.

FIG. 16.—Group of cattle feeding on shinnery oak, Apr. 3, 1917.

FIG. 17.—Cattle feeding on shinnery; a 2-months-old calf in the foreground.

mill pumps are installed, and it was possible by constant observation to get fairly accurate information as to what the cattle were eating and the effect of the feed upon them.

The pastures under observation included a "trap pasture" of about a section (640 acres) of land in which were kept some animals which were the special objects of investigation; a 5-section pasture containing an abundance of shinnery oak; a similar pasture of about 16 sections; and another large pasture containing none of the shinnery.

The general plan of the experiment, as outlined, was as follows:

1. Fifteen head of cattle which had been on pasture and had received in addition more or less cottonseed cake, were to be kept in the 5-section pasture where there was shinnery oak, and fed hay from time to time.

2. In the same pasture a large number of cattle were to be observed which had received no cottonseed cake, but would be given hay with the first bunch.

3. A still larger lot were in the 16-section pasture; they had received no cottonseed cake and would be allowed to graze, receiving no hay.

4. A bunch in the oak-free pasture which were to receive no other forage than that which could be picked up by grazing, and, of course, would eat no oak.

5. A few head were to be taken from the other pastures and put in the trap pasture, where they would be obliged to eat oak if they ate anything, and given no other feed.

The experiment was commenced sufficiently early in the season to follow the cattle from the time the buds began to swell, and was continued until well after the maturity of the leaves.

RESULTS ON 15 MARKED CATTLE IN 5-SECTION PASTURE.

The 15 animals were a part of a small bunch of cattle, mostly cows, which had been picked up in the pastures and put into a small trap pasture near the ranch house, because they were in poor condition. Besides what these animals picked up in the pasture, they had been fed daily from about February 25 to March 26 on cottonseed cake. On March 26, 1917, these animals were turned into the 5-section pasture and fed hay at frequent intervals as they came to water. At times they were driven to water and fed. To get data on individuals 15 of these animals were numbered and marked.

From March 27 to May 6 almost daily trips were made over the 5-section pasture, and observations made on the numbered animals found. Because of the size of the pasture it was not possible to see all of them each time. From April 8 to April 29 these cattle were given an opportunity to get a little alfalfa hay every two or three days or oftener, and most of them took advantage of it. One, No. 784, probably got much less hay than the others. By May 7 all dan-

ger of "oak-brush poisoning" was considered to be past by the ranch owners, and the cattle were run into the 16-section pasture.

None of these cattle were injured by the oak eaten, though observation showed them to be eating a large quantity of it. No. 784 was especially fond of the oak. Between March 31 and April 23 she was seen almost daily either eating oak or lying in the best oak patches. At times she ate the oak very greedily. April 1 she was fed alfalfa, and from April 14 on, it was noticed that she ate other things with the oak, such as bear-grass buds and grass. She was very fond of the bear-grass buds.

On April 4 she was thin and gaunt, a condition which continued until April 16, when she began to look better. It was thought during this period that she might develop into an oak-brush case. From April 16 on, her condition improved.

RESULTS ON OTHER CATTLE IN 5-SECTION PASTURE.

Besides the lot mentioned as having been fed cottonseed cake, something over 200 head of cattle were being run in the 5-section pasture. Of these, 38 were bulls and about 75 were yearlings, the remainder being old cows and calves. The bulls and yearlings had been fed to some extent, the other cattle had not. While making the almost daily rides about the 5-section pasture, close watch was kept of these animals to see what they were eating, and to catch any possible cases of "oak-brush poisoning."

The main diet of practically all these cattle was oak. This was determined by observing the animals grazing, and noting where they were feeding, as shown by tracks. Most of the pastures being drifting sand which filled old tracks almost daily, this observation was easy. The oak in this pasture was kept grazed down while in an adjoining pasture with no cattle it showed good growth.

The buds began swelling first on the higher sandhills and last on the flats. From about March 29, when the buds first began showing to any extent on the sandhills, until near the middle of April, the cattle grazed mostly on the sandhills. By this time the buds had begun to swell on the flats. Some little grass also appeared on the flats at this time, and the cattle began leaving the hills, and were more and more seen feeding on the flats. In other words, they went where they could get the oak buds and young leaves on which they did the main part of their grazing. When grasses and weeds began to show up, however, about the middle of April, they took what they could get of them.

From April 8 on, an opportunity was given these cattle to get a little alfalfa hay every two or three days. Some days they were rounded up at one of the wells and fed, and some days hay was thrown out so that they could get it when they came in to water. Most of them took advantage of it. From the time the observations began until

about the middle of April, these cattle were badly constipated, the feces as observed being in small, hard, dry lumps.

It is significant that none of the cattle in this pasture showed typical symptoms of shinnery poisoning, though their main diet, aside from the hay, was oak. Two or three animals (old cows) were at one time suspected of being affected, as their feces became stringy. This condition soon passed off, however, and they became normal.

RESULTS ON CATTLE IN 16-SECTION PASTURE.

The 16-section pasture lying to the north and northwest of the five sections showed practically the same vegetation, excepting that some of the oak started a little earlier in a few places along its eastern edge. The western half of this pasture, too, was different in that the land was harder and contained no oak. About 400 cattle were here. They had all "rustled" for feed during the winter and were not fed hay at any time.

The grazing habits were exactly the same as those of the cattle in the 5-section pasture. They grazed almost entirely in the shinnery hills, eating the oak from the time the buds began to swell until late in April, when the oak began to show growth on the flats. By the last of April they were working toward the western half of the pasture, where they could get some grass and weeds.

In this pasture seven cattle were seen that showed typical symptoms of "oak-brush poisoning," and five were known to have died of this trouble.

Note should be made here of two other pastures which were examined from time to time. These are a 12-section pasture to the north, and a 40-section pasture to the east, called the Cowden pasture. The 12-section pasture was very similar to the 16-section pasture, and contained about 150 cattle. The Cowden pasture was a typical shinnery pasture and differed from the others only in having a greater abundance of the oak, much of which started growth somewhat before that in the other pastures. This was due to the great abundance of white sandhills.

Two typical cases of shinnery poisoning, both of which died, were seen in the 12-section pasture and seven cases were observed in the Cowden pasture, at least three of which died. Some of the others also doubtless died, as they were in bad condition. The size of the pasture made it impossible to follow up these cases. It is very probable, too, that there were cases which were never seen, in both the Cowden and in the 12-section pastures.

RESULTS ON CATTLE IN OAK-FREE PASTURE.

Just to the west of the 5-section pasture is a 7-section tract spoken of as the hard-land pasture. The sands here are more compact and the pasture contains no shinnery. In other respects, it compares with the other pastures.

Thirty-eight heifers were kept in this pasture during the winter and spring, and allowed to rustle for their living. The feed in this pasture was very short, but the animals managed to get along. They were seen very frequently. No cases of sickness occurred.

RESULTS ON CATTLE IN TRAP PASTURE (OAK ONLY).

Eight cattle were selected for close observation. They were put into a small trap pasture where the only available feed was oak with a small amount of grass and over most of the period a very few weeds. These cattle were followed and notes made on what the individuals were eating and doing, to get as complete a history as possible under the conditions. Three of them had been taken from the 5-section pasture April 8. They were No. 789, a long yearling steer, weight about 600 pounds, and Nos. 790 and 791, both long yearling heifers weighing about 400 pounds each. On April 9, three long yearling heifers, Nos. 792, 793, and 794, were taken from the hard-land pasture and placed with the others. On May 1 two calves about 5 months old, which had been raised by hand, were turned in with the above-mentioned six head, and kept with them.

From the time these cattle were put into the trap pasture until May 16 they were watched closely. Each day, with very few exceptions, they were observed during a good portion of the time they were grazing, and notes taken, special attention being paid to just what each one was eating. Between April 13 and 17 they were herded during the forenoon in a pasture adjoining the trap pasture where the oak was especially abundant. The other days they were watched in the trap pasture.

Cattle Nos. 789, 790, 791, 792, 793, and 794 are of the greatest interest in this experiment, as they were herded on the oak for a longer time than the other two and were held there from the time the oak began to develop until it was in full leaf, or during the period when the shinnery trouble in this region is experienced. No. 793 was the best oak eater in the little bunch, and developed a typical case of shinnery poisoning. Nos. 789 and 790 ate considerable oak, but after a few days' feeding managed to find other things to eat with it. Both kept in good condition except for severe constipation, which was especially marked while they were eating the most oak. Nos. 792 and 794 ate very little oak at any time. Though both were poor because of lack of food, they showed no symptoms of poisoning. They were at times somewhat constipated but much less so than the other cattle.

Nos. 804 and 805 were run with this bunch from May 1 to May 16. During this time they ate considerable oak but got grass and weeds along with it and were fed a little cottonseed cake daily. They were not harmed by the oak, but steadily gained in flesh, and their feecs remained nearly normal.

No. 793, above mentioned, is the most interesting case. On April 9 she was brought in from the hard-land pasture, having had no chance to eat oak, and she was in fair condition. She was marked and turned into the trap pasture to graze and was watered at the house daily. From April 10 to April 25 she ate the oak freely, showing a preference for the buds and young leaves. During this time she ate very little besides oak. She was badly constipated all of the time so far as observed, defecating seldom, and the feces were small in quantity and in small, hard lumps. From April 11 to 14 the attempt was made to get her to drink water containing a small quantity of epsom salt, but as she objected to it the attempt was abandoned and straight well water was given the same as to the others.

The constipation grew worse during the oak feeding. On April 20 the feces were very dry and dark in color; April 22 they were in very dry, hard lumps; April 24 they were in small, hard, ball-like lumps. On April 25 she came in for water by herself about noon. The abdomen was noticed to be drawn up. At 1.30 p. m. she was seen to defecate, passing only four very small balls, each about the size of a walnut. They were at least as hard and dry as a sheep's feces, and contained considerable gelatinous, tough mucus and some blood. She drank considerable water. When walking she moved slowly and had a tendency to drag her hind feet. She was somewhat humped up. She was turned back into the trap pasture but at 5.50 p. m. was again found at the gate of the watering corral. At this time her nose was noticed to be dry, and there was some trembling of the lips and grating of the teeth.

She seemed about the same the next morning, at which time her temperature was 98.8° F., pulse 60 and weak, the mucous membranes of the mouth and nostrils were pale, there was marked trembling of the muzzle, and her nose was somewhat parched. While being driven out to the pasture she passed six or seven very hard lumps of feces, each about the size of a big hickory nut, and these were covered with dry, gluelike mucus and some blood. While in the pasture she showed little inclination to eat anything. During the forenoon she acted as though trying to defecate, but without result until 11.20, when she managed to pass about a quart of hard, lumpy, and dry feces which were bound together with stringy mucus and contained some blood. A hemoglobin test in the afternoon showed 75 per cent, and the blood contained 5,280,000 red corpuscles per cubic millimeter.

On April 27 and 28 her general condition remained the same, and she often acted as though thirsty. There was frequent grating of the teeth. In drinking she would stand about sipping a little water often. She was much depressed, and at times acted somewhat as if nauseated.

On April 29 and up to May 10 when being driven she had a tendency to wander away from the other animals, and had to be urged along. She had a strong tendency to get into the brush and stand until driven out. On the whole she acted much like a "loco."

From April 25, when she first began to show marked symptoms, until April 30 she ate almost nothing. From then until May 8 she ate a little grass and now and then took a very little oak. When she did eat it was in a listless manner. On May 9 she ate better and continued to improve daily, eating mainly grass and weeds with a little oak now and then.

On May 6 at 5 p. m. she was observed to pass about a quart of brownish liquid feces containing neither blood nor mucus. Though she had been watched closely this was the first defecation noted since May 1. At the time, May 6, her temperature was 103° F., the pulse was imperceptible, and her skin was dry and hard.

On May 10 her pulse was still too weak to feel, her hemoglobin tested 80 per cent.

From this time on her condition slowly improved. On May 14 her feces were nearly normal. On May 16 she was still very poor, but her general condition and action were much improved, and she was thought to be on the road to recovery and the experiment was terminated.

Comparing this animal (No. 793) with No. 794, which fed along with it but spent her time hunting grass and weeds, we see a marked difference. No. 793 became very sick with typical symptoms, while No. 794 showed no symptoms, though she remained poor from lack of feed.

In the shinnery country the statement is often made that as soon as the shinnery starts growth in the spring cattle will leave all other feed, even refusing hay, and eat the oak. This idea is erroneous. The oak is the first thing to start growth in the spring, and comes at a time when other feed is practically exhausted. The cattle, too, have existed for a long time on dry, hard feed, and are hungry for something green.

Careful observation shows that the cattle will eat grass and weeds whenever they can find them, and often spend considerable time hunting for them. If held without feed for a few hours they will take the first thing handy, which in this region is oak. After taking the edge off their appetites, they usually keep a lookout for grass and weeds, often refusing the oak. If they have an opportunity to get hay they take it.

The cattle observed showed a very marked preference for oak in certain stages of growth. They obviously liked the swelling buds and minute leaves and flowers, but did not care for three-quarters to fully grown leaves. Usually they would refuse to eat oak at this stage. After the leaves become somewhat older they are said to like them again.

GENERAL RESULTS OF THE EXPERIMENTAL WORK.

SYMPTOMS.

The first symptom, though not always the first one which is noticed by stockmen, is pronounced constipation. The feces are passed very infrequently, are small in quantity, and very hard and lumpy. These lumps may be no larger than a large marble and as dry as the feces passed by sheep. Within a few days, stringy, gluelike mucus is passed with the feces, and this may be somewhat bloody. As the condition develops, the mucus forms a greater proportion of the defecated material, until in late stages, clear mucus may be passed in lumps. In some cases the feces appear at first sight normal in color, but inspection usually shows that they contain a large proportion of mucus. At this time a diarrheal condition may exist.

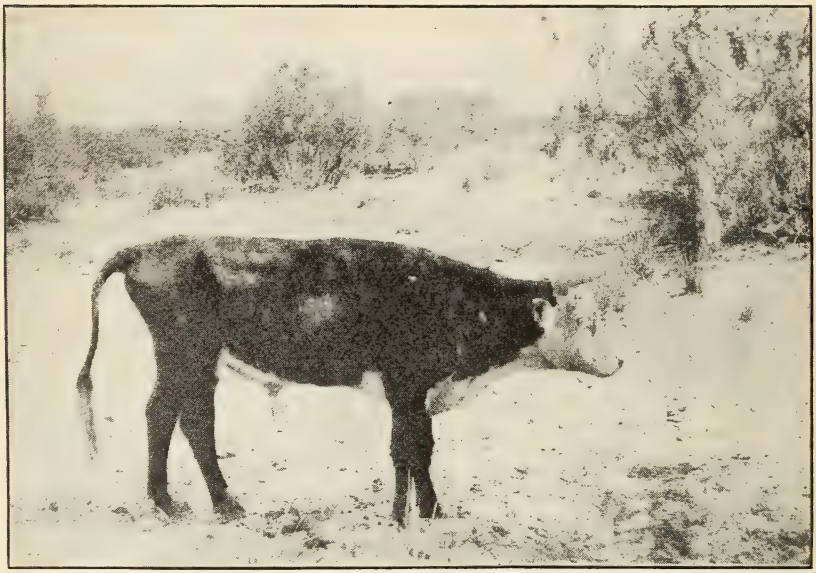

FIG. 18.—A shinneried bull.

Early in the history of the sickness the animal looks gaunt, the coat is rough, and the nose becomes dry and cracked. The attitude, both standing and walking, is peculiar; the head is extended forward and the animal shows depression, discomfort, and sometimes evidence of pain, this pain doubtless being due to the irritated and inflamed condition of the alimentary canal. (Figs. 18 and 19.)

The animal gradually grows weaker and may die at any time from a few days to two weeks or more.

As a rule animals lose their appetites early in the disease, refusing food, but appear thirsty. They will stand about watering places, taking frequent sips of water. This, together with the dry, parched

nose, has given stockmen the idea that they have a fever, but ordinarily, at least, the fever does not exist. They are anemic and often have upon the body swellings containing an accumulation of serum.

The respiration remains about normal during the course of the sickness, but the pulse is weak and slower than in healthy animals. In fatal cases the pulse may become more rapid just before the end.

The temperature in sick animals has a wider variation between morning and afternoon than in healthy cattle, the morning temperature being unusually low. This results in a lower average temperature. This is well shown in figure 10, which gives the curve of temperature of cattle No. 770.

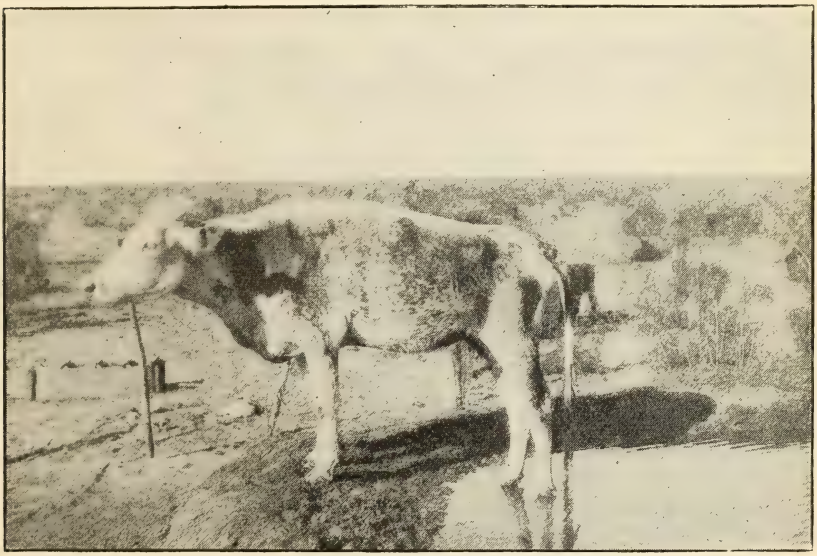

FIG. 19.—A shinneried cow, showing a typical attitude.

It may be noted that the symptoms, in many respects, resemble those of hemorrhagic septicemia, and it seems probable that sometimes the two conditions have been confused. They can be distinguished, ordinarily, however, without laboratory examination, by the fact that the high temperature and pneumonic conditions of hemorrhagic septicemia are absent in the oak cases.

AUTOPSY FINDINGS.

The characteristic pathological condition of the animals which die of oak poisoning is one of severe enteritis or gastroenteritis followed by an edematous stage. The mucosa of the small intestines and abomasum is usually badly inflamed and sometimes swollen, and areas and patches of congestion are usually present in the cecum and rectum. This congestion may even extend to the serous membrane of the intestines.

The animals are anemic, and pronounced accumulations of serum are usually found beneath the skin and in connection with the serous surfaces. This in the cases autopsied was especially pronounced in the mesentery, which was much thickened and contained a jellylike deposit which in some cases forced the serous layers apart. The swelling ruptures numerous blood vessels, causing hemorrhagic spots.

The heart had many petechiæ or small hemorrhages on its surfaces, and there was sometimes a serous accumulation on its surface or on the pericardium.

The abdominal cavity of one animal was distended with a serous accumulation. The kidneys may show small hemorrhages.

One animal autopsied appeared to have passed by the acute stage of congestion. The intestines were darkened from an old congestion, and the thickened mesentery was adherent in places to the body wall, as were the liver and kidneys. In this case no serous deposits were found under the skin, but the skin was unusually adherent to the flesh.

MICROSCOPIC PATHOLOGY.

The most prominent lesions in cattle killed by oak-brush poisoning occur in the alimentary tract and the kidneys. The abomasum and the intestines show a condition of gastroenteritis, often in a very severe form. The part of the alimentary canal where this inflammation is exhibited in the greatest intensity varies in different animals. The intestines are inflamed or show changes which follow this condition, such as degeneration of epithelial lining and glandular tissue, increase in connective tissue especially in the mucosa, and edema of the intestinal walls, which are often thickened. Both small and large intestines are involved.

The abomasum or fourth stomach in most cases shows changes similar to those found in the intestines.

The kidneys are inflamed and show a pronounced edema, which is indicated by shrunken glomeruli, enlarged tubules, and numerous casts in the tubules. In some cases the epithelial cells lining the tubules appear stretched and flattened, but in most cases they are more or less degenerated. The epithelium in many tubules is sloughed off from the basement membrane. The enlarged tubules give the kidney sections a cystic appearance. There is an increase in the connective tissue between the tubules.

Most of the other tissues may be edematous. This condition is frequently seen in the heart, liver, pancreas, and various serous tissues. In connection with these edematous swellings hemorrhagic spots often occur.

LENGTH OF TIME NECESSARY TO PRODUCE HARM FROM OAK FEEDING.

Observation on the range and experimental feeding both show that some cattle may eat oak brush for a long time with no definitely bad effect. Some will even eat oak exclusively with no harm. Generally

speaking, those that are injured show the results only after eating a considerable quantity through a rather prolonged period. The observations on the shinnery oak showed that symptoms resulted after the animals had been feeding from 16 to 35 days.

In the experimental animals, which were fed exclusively upon oak, constipation was noted in 2 cases in 6 days, and in the others definite symptoms appeared in from 8 to 13 days. In the 2 fatal cases one died in 39 days and one in 17 days. Of course, under ordinary circumstances, it would not be expected that range animals would show symptoms so soon as the subjects of these experiments, for the feeding of the animals in the corrals was intensive, and of oak exclusively.

Permanent injury may not follow from oak. Some animals injured by oak feeding may linger a long time, and eventually die. In some cases, however, favorable conditions may bring about recovery with no evidence of permanent injury. No. 704, which was the subject of experiment in 1916, was observed through the summer of 1917, and made normal gains.

EFFECT OF EATING OAK WITH OTHER FEEDS.

The experimental work at the Salina experiment station in 1916, 1917, and 1918 showed conclusively that oak could be eaten not only with no harm but also with apparently distinct benefit if other additional forage was provided. As small a quantity as 3 pounds of alfalfa hay daily, with the oak, prevented injury and maintained the weight of the animals. Range experience in Utah clearly indicated the same thing. Observations in the handling of cattle on the "shinnery" ranges near Monahans, Tex., also demonstrated the beneficial effects of comparatively small feedings of hay.

In this connection it may be mentioned that W. R. Morley, of Datil, N. Mex., told Assistant Botanist Eggleston that although the cattlemen of that region had heavy losses from oak poisoning, he himself had avoided them by feeding hay and a small quantity of cottonseed meal as long as his cattle returned to the corrals.

ACTIVE PRINCIPLE OR PRINCIPLES CAUSING OAK-BRUSH POISONING.

Very little chemical or pharmacological work has been done to determine the fundamental cause of the injurious effects of oak-brush forage; this matter is still under investigation, but the results are not sufficiently definite to report.

It has been assumed by some that tannin or the tannates might be responsible for the trouble. On this account it seemed best to perform some experiments with tannic acid. Two animals were used, cattle Nos. 755 and 815. It was impossible to estimate the quantity of tannin obtained by an animal feeding upon oak brush, for it was found impracticable to handle the animals in such a way as to know how much oak they were eating. It was planned to give to one

animal 25 grams (0.055 pound) and to the other 50 grams (0.11 pound) daily per 1,000 pounds of animal.

The 25-gram dose was given to No. 755, being administered by drench daily in 3 doses of 8.33 grams each. This was continued from August 4 to September 2, producing no effect upon the animal.

The 50-gram dose was given to No. 815. This, as in the case of No. 755, was divided into 3 daily doses, and was continued from September 5 to September 10; September 11 only 2 of the doses were given, and September 12 only 1. From September 13 to September 17 the 3 daily doses were resumed, and on September 18 and 19 only 1 dose was given. During the experiment the animal was fed upon hay. No symptoms were noticed, but on the morning of September 20 it was found dead. It was very much bloated and it was evident that it had vomited profusely. In the autopsy there were found hemorrhages in the trachea. The lungs were congested, there were hemorrhages and infiltrations of serum in the muscular coats of the esophagus, the first and second stomachs were distended with gas, there were hemorrhagic patches in the duodenum, and congested spots in the jejunum, ileum, cecum, and rectum. There were hemorrhages on the surface and interior of the thymus. The superficial blood vessels of the brain were fuller than normal and there was a possible excess of spinal fluid.

The animal had not shown general symptoms which could be considered comparable with oak poisoning, but possibly died from the effect of the tannic acid.

These experiments indicated that the cause of oak-brush poisoning could not be tannic acid, and made it very doubtful whether the tannin in the oak was the fundamental cause of the trouble.

SUMMARY OF CONCLUSIONS FROM EXPERIMENTAL WORK.

1. Continuous feeding on oak leaves may produce sickness which sometimes has a fatal termination. Only a small percentage of the animals in a given range are injured.

2. The specially marked symptoms are constipation, feces containing mucus and blood, emaciation, and edema.

3. A diet composed exclusively of oak leaves does not form a sufficiently nutritious diet to permit normal gains in weight.

4. Oak leaves with a small quantity of other feed may provide a maintenance ration. It has been found experimentally that as small a quantity of alfalfa hay as 3 pounds daily will supplement the oak for this purpose.

5. Oak leaves may produce injurious effects at any season. Most of the cases, however, occur in the spring because on the range at that time there is a scarcity of other forage and the young oak leaves are attractive. While cattle later in the season may eat largely of oak, more or less other forage is available and no harmful results are experienced.

6. The "summer sickness" of the Utah ranges is identical with so-called oak-brush poisoning.

DISCUSSION OF RESULTS WITH RELATION TO PRECEDING INVESTIGATIONS.

The conclusions stated above are derived entirely from the results of range investigations and experimental feeding in the western part of the United States. As has already been stated, very little has been published with regard to oak poisoning. The statements of Barnes, 1913, and of The Breeder's Gazette, 1909, cover about all that has been published concerning oak poisoning in the United States, except newspaper notices. The study of oak leaves by Mackie, 1903, gave results that are in entire harmony with those obtained in the feeding experiments at the Salina experiment station, reported in this bulletin.

The extended account by Cornevin is the only detailed statement of oak poisoning that has ever been published. A comparison of his statements with the results obtained in our experiments shows a general agreement, but with certain marked differences. Cornevin states that the animals, in addition to the constipation with hard feces, which is so marked a symptom in our experimental work, exhibit colic, trembling, and bloody urine. These symptoms did not appear in the experimental animals in Utah and Texas; the microscopic examination, however, showed marked nephritis. Cornevin states that the pulse is "hard" and that the animals have fever. In the Salina cases the pulse was weak rather than hard and there was no fever, but, on the contrary, the temperature was somewhat lower than normal. It may reasonably be questioned, however, whether Cornevin's statement in regard to fever was based on any exact observations, as the use of the clinical thermometer was not very common at that time. Apparently the European animals were affected in a much more acute and severe manner; this is also shown in what Cornevin says of the "lesions," which correspond very well to those observed in Utah and Texas, but are more marked in the French cases.

A large part of Cornevin's description is taken up by an account of the condition of the urine and a discussion, largely theoretical, of the probable relation of the tannic acid in the plants to the hemoglobinuria. This phase of the subject is reserved for a later consideration, after some unfinished experimental work has been completed. So far as the work has gone there appears to be no marked discrepancy between Cornevin's account and the results obtained.

PRACTICAL CONSIDERATIONS FOR RANGE GRAZING.

So far as these investigations have gone the following statements appear to be justified:

1. During the summer and fall the oak-brush ranges of Utah can be used for grazing, not only with no harm to cattle, but with positive benefit.

2. The admission of cattle to oak-brush ranges before grass has started practically compels the cattle to eat oak, as that is the only forage available. To make certain that there is no loss from oak brush at this time, it is important that an examination of the condition of the range should precede the admission of cattle, rather than that they should be admitted on a fixed date, inasmuch as seasons differ markedly in the advancement of the vegetation. After the grass has started so that the cattle have an opportunity to get something in addition to the oak, there is little danger of oak poisoning.

3. On the shinnery ranges, as on the oak ranges in Utah, the danger to cattle is from an exclusive diet of oak. The shinnery ranges can be used without loss provided a comparatively small quantity of other feed is available.

4. The loss from oak on an oak range is estimated at from 2 to 3 per cent. Considering the handling of range cattle from a cold-blooded business standpoint it may, under some circumstances, be more profitable to stand the loss rather than to provide the additional feed. It should be remembered in this connection, however, that underfeeding tends to injure cattle permanently and prevent normal gains in weight, so that the tendency among many stockmen to gamble on the chance of getting cattle through the winter and spring on short feed is liable to lead to disastrous results.

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